work. To science the able discussions of causes and effects, of climatic relations to geology, geography, and agriculture, of water-supply, etc., are the most attractive features. The pages devoted to underground water resources are specially strong. The only regret is that the paper is not finished.

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The Bauxite Deposits of Arkansas. By CHARLES WILLARD HAYES, U. S. Geological Survey, Twenty-first Annual Report, Part III, pp. 435–472. Maps and plates.

COMMERCIAL deposits of bauxite have been known in Arkansas since 1890, when they were first discovered by the State Geological Survey. The present report by Dr. Hayes represents, however, the first detailed systematic study of these deposits, and its appearance when developments are just beginning in the area, makes it a very timely one.

Preliminary to the description of the Arkansas deposits proper, the report opens with a brief summary of the "distribution of bauxite deposits in the United States." The Arkansas deposits are limited to a small area twenty miles long and five or six miles wide, lying south and southwest of Little Rock, in the adjacent parts of Pulaski and Saline counties. The most important deposits of the state are grouped into two districts, with less important isolated ones between. The general geologic and physiographic relations of the region are recounted in some detail, derived largely, as the author says, from the state survey reports. Three distinct groups of rocks are made out, namely, the Paleozoic sediments in the northwest, the Tertiary and recent sediments on the southeast, and areas of intrusive igneous rocks in the two bauxite districts. The Paleozoic rocks are similarly folded and closely resemble those of the Alabama-Georgia-Tennessee area of the southern Appalachians. The region was probably several times reduced to a nearly featureless plain, and sometime after the folding, probably, during Cretaceous, the igneous rocks were, according to Williams, intruded. Beginning with the Cretaceous, the region was several times invaded by the sea and Tertiary sediments still form a considerable part of the area.

In the detailed description of the deposits, the two districts are

separately described in some detail, and certain peculiarities possessed by each are pointed out. The few scattered isolated deposits are likewise described.

In the Bryant district, which is the most southwesterly one, the bauxite occurs in two distinct forms: (*a*) granitic bauxite, and (*b*) pisolitic bauxite. The granitic bauxite forms the basal portions of the beds, and in most cases rests immediately on a layer of kaolin, derived by the ordinary processes of decay from the syenite. The bauxite is spongy in texture with no trace of the pisolitic structure, but showing partial traces of the granitic structure in which the individual feldspars are replaced by a porus skeleton of alumina. It is probable, says Hayes, that this type of bauxite is in every case derived directly from the syenite by the decomposition of the feldspar and the eleolite, and the removal in solution of silica, lime and alkalis, the alumina alone remaining of the original constituents. The pisolitic type is more uniform than that of the Georgia-Alabama region and forms the upper parts of the beds. The two forms of ore are not separated, as a rule, in the same section, by any sharp and definite line.

In the Fourche Mountain district only the pisolitic type of the ore has been found, which, when nearest the syenite margin, rests on a layer of kaolin as in the Bryant district. Those deposits more distant from the syenite margin are probably interstratified with sedimentary beds of Tertiary age.

The scattered isolated deposits found between the two districts resemble in their mode of occurrence the Georgia-Alabama deposits.

The deposits are in beds or layers, which range in thickness from zero to forty feet, and have a probable average thickness of ten to fifteen feet for the two districts, and two to five feet and more in case of the isolated bodies of ore.

In chemical composition the Arkansas bauxite varies within wide limits. The granitic type is the purest, and in selected samples contains less than 3 per cent. of silica and 1 per cent. of iron oxide, and corresponds in composition to the formula $Al_2O_3 3H_2O$ — the trihydrate of alumina. In the white bauxitic kaolins the silica ranges as high as 20 to 30 per cent., and in extreme cases the iron oxide reaches 50 per cent. in some of the highly ferruginous types of the ore.

Concerning the origin of the Arkansas bauxite deposits Dr. Hayes says that they are so intimately associated with the igneous rocks of the region that genetic relationship between the two is at once sug-

gested. The characteristic pisolitic structure of the upper portion of the deposits indicates chemical precipitation. The granitic bauxite forming the lower or basal portions of the beds, and the bowlders, are evidently of a different origin. The bauxite was probably laid down on the syenite rather than on the kaolin, as there is no indication that the kaolin is an intermediate product between the fresh syenite and the bauxite.

In his report on the igneous rocks of Arkansas Dr. J. Francis Williams suggests two theories for the accumulation of the bauxite. First, that the bauxite was formed by the decomposition of a bed of clastic material, derived principally from the syenite. The second, which he regarded as the most probable one, involved the action of the waters of the Tertiary sea on the still highly heated igneous rocks, in which, under high temperature and pressure, the constituents of the syenite were dissolved and brought to the surface in solution, the water emerging as hot springs. In the discussion of these theories Dr. Hayes points out serious difficulties to both.

In the last part of the report Dr. Hayes treats of the "Economic Relations" under "Development;" "Amount of Ore," which includes a tabular statement of the estimate of the amount of ore in the Arkansas bauxite region, and, according to the author's calculations, shows the total amount estimated in outcrops to be 6,608,500 long tons, and the total amount under cover 43,711,200 long tons; "Quality of the Ores;" and "Mining and Preparation of the Ore for Market."

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